Instrumentation and Monitoring: Design Considerations for Teams

Introduction

Measurements of temperature, humidity, electric power, and illuminance determine a significant portion of the Solar Decathlon scores. This document describes what the Organizers will install in teams' houses and how teams can help facilitate this work.

The location of sensors is determined via a negotiation between each Solar Decathlon team and the Organizers. The Organizers negotiate in good faith and try to achieve an equitable outcome for all teams. There is significant flexibility regarding location and wiring details. The negotiations will start well before the Event, but some details may be worked out at the last minute. Teams are welcome to propose specific locations as their house designs progress. Teams may also ask the Organizers for recommendations. The Organizers will start making proposals for sensor locations soon after they review the teams' Drawings and Submittals.

Accommodating instrumentation is not directly part of the scoring. However, sensors must be installed or teams can't get a score in the performance-based Contest Activities. Consequently, the Organizers suggest that teams accommodate the sensors sooner rather than later.

In the following sections, the primary components of the monitoring system are described:

Datalogger

The datalogger box is 14 in. (36 cm) wide, 16 in. (41 cm) high, and 8 in. (20 cm) deep. It weighs about 12 lb (5 kg). The door hinge is on the left when facing the box. The Organizers are currently planning to use wired (as opposed to wireless) sensors, so a route must be provided for running sensor wires from each sensor location to the datalogger. Wires from sensors are usually inserted through the conduit bushing in the bottom of the datalogger box. These wires are usually not installed in conduit. The datalogger box is usually mounted in a vertical orientation using screws to attach it to a wall surface at a height above the floor that provides convenient working access. The typical location for the datalogger box is in a utility room or closet, near the main AC breaker panel. The box can be mounted horizontally or upside down if the normal orientation is not available. The datalogger requires a small amount of electric power (approximately 2 watts) from the house's electric system, with the burden on each house being the same. A standard 120 VAC receptacle is usually used to supply this power. The Organizers communicate with the datalogger via a wireless modem located inside or adjacent to the datalogger box. An external antenna may be required for successful wireless modem communication. However, in the past, no external antennas were required.

Electric Power Meters

Up to six (6) separate AC electric power measurements will be made in each house. The AC power meters are mounted in a standard electric panel box. The box is 15 in. (38 cm) wide, 20 in. (51 cm) high, and 4 in. (10 cm) deep. The door hinge is on the left. This box is

usually surface-mounted adjacent to the main AC electric panel in the house. Wires for voltage taps and current transformers will be installed between the meter box and the circuits inside the main AC panel. Each watt-hour meter unavoidably uses a small amount of power (1–2 watts each) from the house, with the burden on each house being the same. For the installation of these meters, it is helpful to have extra room for the current transformers and extra breakers for the voltage taps.

If significant end-uses are supplied with DC rather than AC power, the Organizers plan to install shunts and voltage dividers inside the teams' DC power panels to measure the DC power. Measurement of DC power is more idiosyncratic than measurement of AC power.

With the exception of lighting, electric power consumption of separate end-uses is not directly scored in the Contests, but the Organizers are still very interested in separately measuring the electric power used in performing the tasks for each Contest Activity. The segregation of end-uses provides a more interesting comparison among the houses and may give teams more information to optimize the performance of their houses during the Competition. Therefore, it is important for teams to arrange the electrical circuits according to the Contest Activity end-uses. For example, if the dishwasher is on a separate circuit than the refrigerator, the measurement of electric power of each individual circuit will provide a more interesting interpretation of performance than if both appliances were on the same circuit. The Organizers expect the end-use measurements to include refrigerator, clothes washer, clothes dryer, dishwasher, hot water, lighting, and electric car.

Part of the scoring of Contest 8: Lighting depends on the measurement of electric power, so it is important that the lighting circuits are not contaminated by any other end-uses. The "Standard Usage Patterns" Contest Activity requires that all interior lighting used in the "Electric Lighting Quantity" Contest Activity be connected to dedicated circuits. "Dedicated" means that no other electric end-uses are connected to the dedicated lighting circuits and no interior lights are connected to circuits other than the dedicated lighting circuits. The Organizers will install current transformers on each of the dedicated AC lighting circuits to measure the lighting power as a separate end-use. If DC power is used for lighting, the Organizers will install shunts and voltage dividers for each dedicated circuit. Teams should clearly identify the dedicated lighting circuits and any receptacles connected to those circuits. The Organizers will verify that these circuits are "dedicated."

Main Battery Shunt

The scoring for Contest 9: Energy Balance requires measurement of the DC electric energy flow into and out of the battery bank. The Organizers plan to use a shunt to measure current and a voltage divider to measure the battery voltage. The installation of the main battery shunt can be time consuming because the battery cables are large and inflexible and there is typically limited space available to make the connections. Many commercially fabricated DC load centers are available with a shunt already installed. If a team's DC panel already has a shunt, the Organizers will want to share the output signal from the shunt. If the team's panel does not have a shunt, the Organizers will send one so it can be installed as the system is being built.

The Organizers need a route to run wires from the shunt and voltage divider to the datalogger. The DC load center is frequently located in the same utility space as the datalogger, so surface mounting of sensor wires is usually straightforward and appropriate.

This description of the Energy Balance monitoring approach applies to the case in which a team has only one battery bank. If a team's design includes more than one battery bank, the Organizers will duplicate the measurements for each battery bank. However, to avoid placing an excessive burden on the Organizers installing instrumentation, systems should have just one main battery bank. If a team is proposing to use more than one battery bank, it must provide justification and that justification must be approved by the Organizers.

Light Sensors

Contest 8: Lighting requires that a minimum average lighting level be maintained on the work surface of the home office desk during certain hours. The Organizers will install a photometer on the desk to continuously measure the illuminance on the horizontal work surface. The photometer with its base is about 3 in. (8 cm) in diameter and about 1 in. (3 cm) high and requires a wire to connect it to the datalogger. The Organizers will negotiate with each team to determine a specific location that is representative of the task lighting and accommodates other normal activities on the desk.

Temperature and Relative Humidity Sensors

A significant part of the scoring in Contest 5: Comfort Zone is derived from the measured dry bulb temperature and relative humidity inside the house. The Organizers plan to use a temperature and relative humidity sensor mounted inside a radiation shield to make this measurement. The sensor will be placed in a location that is representative of the temperature and humidity conditions through the entire house. This location will usually be between 4 and 5 ft (1 and 2 m) above the floor in the largest open room of the house. A location adjacent to a standard house thermostat is typical. In a closed bedroom, on an exterior wall, near the floor or ceiling, or near a window are all highly unlikely locations. If there is clearly more than one zone in the house, the Organizers will install more than one sensor. The objective of Contest 5 is to heat and cool the house (not to heat and cool the temperature sensor) and to maintain comfort conditions throughout the entire space.

The temperatures inside the refrigerator and freezer will be measured with thermocouples. These measurements typically require the placement of a small wire through the refrigerator or freezer door so that the gasket closes around the wire. This approach was used in the past with satisfactory results. The Organizers will identify a route for the thermocouple wires to be run from the datalogger to the refrigerator and freezer. If a team is concerned that jamming wires in the door will significantly impair the thermal performance, note that all teams are subject to the same installation approach. If a team is going to use a non-standard door gasket, the Organizers need to be made aware of it.